Evaluating gender impacts in employment: A CGE framework for policy makers

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Detailed representation of industries and regions has underpinned the policy relevance and hence the success of many CGE models developed over the last four decades, including the VU, TERM, VURM and USAGE models (Centre of Policy Studies), and the GTAP model. A natural extension to the industry detail is the incorporation of significant occupational detail, and from here it is a small step to expand the framework into demographic detail. In this paper we introduce VUEF-G, a variant of the Victoria University Employment Forecasting model which accounts for gender. We propose a labour supply framework that accounts for time use by men and women, and illustrate the framework with three examples.

Australia was a pioneer in gender budgeting but has fallen behind in recent years. We hope that VUEF-G may provide a systematic and serviceable framework in which gender impacts become as much a part of CGE-based policy analysis as industry and regional impacts.

1 Introduction

Detailed representation of industries and regions has underpinned the policy relevance and hence the success of many CGE models developed over the last four decades, including the VU, TERM, VURM and USAGE models (Centre of Policy Studies) and the GTAP model. The level of industry detail in these models is rarely matched by significant occupational or demographic detail. Although the aggregate supply of labour may be appropriately constrained in these models, a lack of occupational detail gives rise to highly elastic labour supply for individual industries, as the share of labour accounted for by any industry in a detailed industry model is typically small. The problem is addressed in many CGE models [e.g. P. Dixon and Rimmer (2018)] by putting constraints around the supply of labour by occupation. The constraint typically involves dividing the labour force into cohorts with fixed characteristics, and using these characteristics to limit occupation-specific labour supply. For example, P. Dixon and Rimmer (2018) use existing occupation and immigration status as the fixed characteristics and use a matrix of transition probabilities to constrain supply to occupations in the model solution. This approach also allows for transition into and out of unemployment.

The VUEF model [J. Dixon (2017)] adopts a slightly different approach, in which skills (based on educational qualifications) provide the fixed characteristics of the labour force. The most recent version of VUEF identifies 115 industries employing 97 occupations, supplied by 67 skill cohorts. Based on relative occupational wages, each skill cohort chooses a revenue-maximising combination of occupations subject to a CET frontier, giving rise to an upward-sloping supply curve for each occupation. As with many similar models, each industry has a downward sloping demand curve for each occupation. In VUEF, occupation-specific wages adjust to clear the markets for occupations.

In this paper we propose a variant of VUEF, VUEF-G, which adds a gender dimension to the existing VUEF model. We formulate labour supply in a labour-leisure framework in which we also introduce home-produced domestic services ("housework"), which covers activities such as cleaning, cooking, and caring for family members. We assume that households choose leisure, domestic services and consumption to maximise utility subject to three constraints: (i) a time constraint on total labour, leisure and housework; (ii) a budget constraint equating household wage income to expenditure on consumption (other than domestic services) and purchased domestic services; and, (iii) a production constraint for domestic services, which are a combination of home-produced and purchased domestic services.

In the remainder of this paper, we set out the theoretical considerations in building endogenous labour supply into the VUEF-G model. We then offer three examples of gender budgeting in a CGE framework: an economy-wide productivity gain from labour-saving technical change, an agri-food export boom, and a cut to the rate of company tax. In each of these examples, we work from the macroeconomic effects through to the industry effects, and finally to the employment and wage impacts for men and women.

2 Methodology

2.1 Background

The starting point for the VUEF-G is the VUEF model [J. Dixon (2017)]. This model contains all the features of a standard MONASH – style dynamic CGE model [P. Dixon and Rimmer (2002)], namely:

1. equations describing demand for domestic and imported goods and services by industries, investors, households, government and the rest of the world;
2. equations describing demand for factors of production by industries;
3. market clearing conditions for all goods and services and factors of production;
4. zero pure profit conditions determining basic prices of goods and services;
5. equations linking basic and purchaser prices through taxes and margins;
6. equations linking industry-specific capital supply to investment;
7. equations linking investment by industry to expected rates of return; and
8. equations to ensure that wage adjustment is sticky.

These equations are described in detail in many references including P. Dixon and Rimmer (2002), Horridge (2014) and P. Dixon *et al*. (1982).

VUEF adds to the standard MONASH framework a detailed specification for labour supply. In VUEF, the working-age population is disaggregated into many skill groups. Each skill group chooses its occupational composition of employment by maximising wage income subject to a transformation frontier.

VUEF therefore adds to the standard CGE framework a method for determining *occupational* employment and wages. However, participation and unemployment rates by *skill group* are typically exogenous, or simply indexed to their national equivalents. This treatment fails to acknowledge the likelihood that labour supply is more elastic among part time workers, particularly women.

In this paper, we describe how to augment this equation system with a gender-lensing framework. As we describe, this is achieved by adding equations that enable labour supply by skill group to be endogenised, and by disaggregating every skill group by gender.

2.2 Labour supply by skill and gender

2.2.1 General framework

Subject to an exogenously determined wage (W), price of bought services (A), price of consumption (P), and time constraint (=1, an arbitrary setting), we choose L (labour), R ("rest" or leisure), H ("housework"), C (consumption excluding services), S (services) and B ("bought" services) to maximise utility (U), where:

$U = f(C, S, R),$	(1)

subject to the constraints:

$W.L = P.C + A.B,$	(2)
$R + H + L = 1,$	(3)

and

$S = g(H, B).$	(4)

The first order conditions of this system are:

$S = g(H, B),$	(5a)
$W.L = P.C + A.B,$	(5b)
$R + H + L = 1,$	(5c)
$g_H = \frac{f_R}{f_S},$	(5d)
$\frac{f_R}{f_C} = \frac{-W}{P},$	(5e)
$\frac{g_B}{g_H} = \frac{-A}{W}.$	(5f)

Equations (5a) – (5f) are a system of 6 equations which are solved for 6 unknowns.

In VUEF-G, 56 skill groups[1,2] are identified and disaggregated into male and female. The equation system (5a) – (5f) is embedded within VUEF-G and parameterised by data across the 112 (2*56) skill/gender cohorts. The model computes a unique value for the elasticity of labour supply with respect to wage for each skill/gender cohort. The framework is able to capture differences in male and female labour supply elasticities. These arise because of differing incidence of part time work and housework across gender and skills groups.

2.2.2 Functional form in VUEF-G

In VUEF-G, we use a CES function to describe both utility (*f*) and service production (*g*). As with VUEF and VU models more generally, we assume that the initial solution to the model is known, and we solve the model in percentage deviations away from the initial solution. This approach has the advantage of simplifying equations (5a)-(5f): they become a system of linear equations (6a) – (6f), which are easily solvable. VUEF-G is solved with the GEMPACK software [Harrison and Pearson (1996)]. In equations (6a) – (6f), we adopt the convention whereby lowercase variables represent the percentage-change-form of the previously defined uppercase variables:

$s = S_H^S h + S_B^S b,$	(6a)
$w + l = S_C^Y(p + c) + S_B^Y(a + b),$	(6b)
$S_H^T h + S_L^T l + S_R^T r = 0,$	(6c)
$(\eta - 1)(h - s) = (\rho - 1)(r - s),$	(6d)
$(\rho - 1)(r - c) = (w - p),$	(6e)
$(\eta - 1)(h - b) = (w - a).$	(6f)

In equations (6a) – (6f), we have also defined:

- S_H^S and S_B^S as the proportions of housework and bought services in service production, respectively;
- S_C^Y and S_B^Y as the proportions of consumption and bought services in total expenditure, respectively;
- S_H^T, S_L^T and S_R^T proportions of housework, labour and leisure in total time, respectively;

[1] The 56 skill groups comprise of 11 qualification fields cross classified by 5 qualification levels, and a single category for no post school qualification.

[2] Note that VUEF has 67 skill groups. In VUEF-G, all Certificate qualifications are counted as a single qualification level, whereas in VUEF, Certificate I-II qualifications are separated from Certificate II-IV qualifications.

- η as the CES parameter in the services production function; and,
- ρ as the CES parameter in the utility function.

Labour supply elasticities can be derived by combining (6a) – (6f) and substituting out all variables except labour supply (*l*) and the wage (*w*). This leads to the following expression for labour supply:

$$l = \left\{ \frac{\rho}{1-\rho} S_R^T + \frac{\eta}{1-\eta} S_H^T + \frac{S_H^S}{(1-\eta)} \frac{(\rho-\eta)}{(1-\rho)} \left(S_R^T S_B^Y - S_H^T S_C^Y \right) \right\} w, \qquad (7)$$

where the bracketed term in equation (7), i.e., the term in { … }, is the elasticity of labour supply with respect to the wage.

Examining each component of the labour supply elasticity in turn, we find that the shares of rest (S_R^T) and housework (S_H^T) in time both have a positive relationship with the labour supply elasticity. This is intuitive, because cohorts who have less time already allocated to paid employment, have more scope to increase their hours of paid employment in response to an increase in wages. Thus a higher labour supply elasticity is derived for cohorts which allocate less time to paid employment in the initial data. The extent to which cohorts can substitute their time into work (and away from leisure) is governed by the utility parameter, ρ. The extent to which cohorts can substitute their time away from housework is governed by the services production function parameter, η.

The third and final term in equation (7) is more complex. We would normally expect $(\rho - \eta)$ to be negative, as the tendency of cohorts to substitute away from housework and into paid work is greater than the tendency to substitute away from leisure. A sufficient condition for the third term in equation (7) to be positive is if $S_R^T S_B^Y < S_H^T S_C^Y$. This condition can be rearranged, to show that the third term in equation (7) is positive if $\frac{S_H^T}{S_R^T + S_H^T} > S_B^Y$. This is equivalent to saying that the final term in (7) is positive if the share of non-labour time devoted to housework is greater than the share of the budget allocated to bought services. If this condition is met, the given cohort has more scope to substitute towards bought services in response to an increase in the wage.

2.3 Calibration

At this stage of development, calibration of the model is based on the 2016 Australian Census of Population and Housing. Calibration requires estimates for hours worked in paid employment and in unpaid domestic work, across both the skill and gender dimensions, all of which are available from the Census. Calibration also requires estimates of purchased services. The distribution of services and consumption across skill groups is estimated. Given that the gender and labour supply aspect of the model is still under development, assumptions were applied that may be revisited when resources permit.

2.3.1 Time use

We require initial data for S_H^T, S_L^T and S_R^T, which are defined in section 2.2.2 and are (respectively) equal to the proportions of housework, labour and leisure in total time, for every skill-gender cohort. This data is derived from the Australian Census (2016). Estimates are illustrated in Figure 1.

We assume that the time-use allocation applies to a 5-day week with 12 hours per day. Beyond this, we assume that time-use is non-negotiable and outside the scope of the time-use module.

Population counts by skill-gender cohort and labour force status were used to derive the proportion of time devoted to labour. Full time workers were assumed to work two-thirds of the time (i.e. 40 hours per week), and part-time workers one-third. Unemployed and non-participating people of working age were assumed not to work at all. An estimate for S_L^T for each skill-gender cohort was derived from a weighted sum of all people of working age in the cohort. Typical values for the highly-qualified male cohorts were around 0.5, and for the highly-qualified female cohorts, around 0.375. The less educated cohorts (those with Certificate I-IV or no post-school qualifications) had lower values of S_L^T, at around 0.4 for men and 0.3 for women.

Estimates of time spent on "housework" are derived from Australian Census (2016) data on time spent on unpaid domestic work, and time spent caring for children. Australian Census (2016) data gives frequencies for several ranges of hours per week spent on unpaid domestic work. To begin, we calculated an average for each cohort, again assuming that the week consists of 60 hours. For the top range, "30 hours or more", we assumed that the average was 32 hours spent on unpaid domestic work. For all other ranges, we adopted a convention whereby the median of the range was set as a point-estimate.

We constructed a “childcare index” to account for time spent caring for children. The census asks whether individuals spent time caring for their own children; other children; or, their own children and other children. We assign time-use weights of 0.5 for own children, 0.2 for other children, and 0.3 for own and other children. We assume that people caring for their own children do so for a larger proportion of their time than people caring for other children (perhaps grandchildren). People caring for their own and other children account for only 0.6 per cent of the population, so the weight assigned to this category is not critical in driving model outcomes.

The housework and childcare proportions are aggregated to provide an estimate for S_H^T, the share of time allocated to housework, for every skill-gender cohort. This is around 0.32 for males of all skill levels, and 0.22 for females of all skill levels. While there is very little variation across skill levels, there is a clear difference between male and female time allocated to housework.

Leisure time, S_R^T, is the remainder after accounting for labour and housework. This share is between 0.3 and 0.45 for most skill-gender cohorts, and there is no obvious difference between the male and female shares.

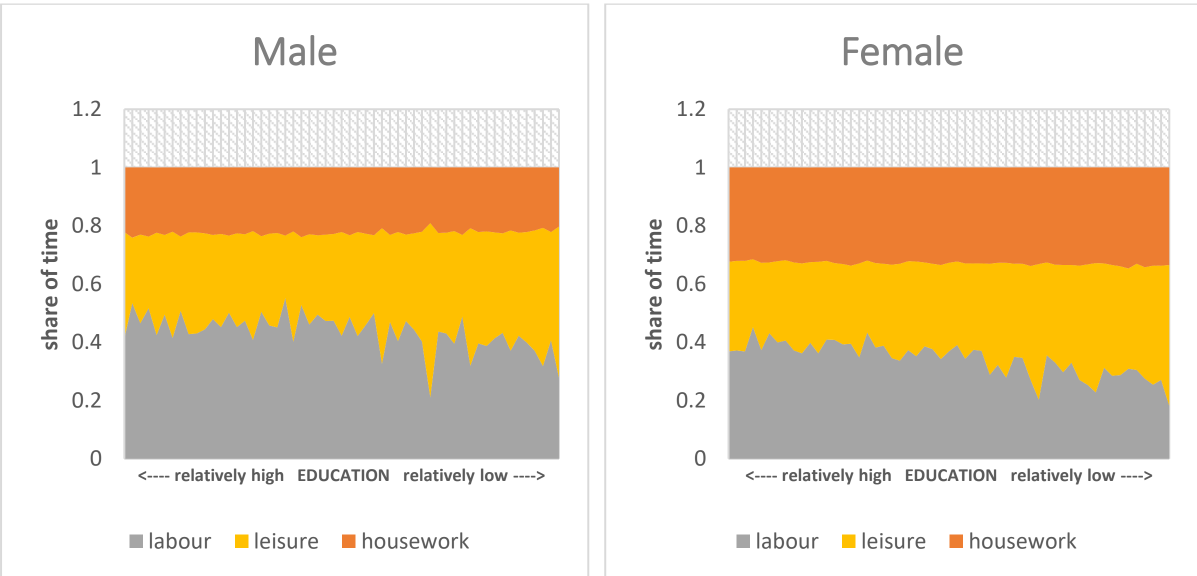

Figure 1: Time use, male and female by education cohort (level and field). Source: Australia Census (2016) and author calculations.

2.3.2 Budget shares

The household budget is divided into S_C^Y and S_B^Y, which respectively represent the proportions of consumption and bought services in total expenditure. In this context, "consumption" excludes bought services. At this stage of development, there is no link between these budget shares and the household budget shares used in the core CGE model. We plan to investigate this link at a later stage of the model development process.

We reason that the share of bought services in the household budget is relatively low for cohorts with low labour hours (as they also spend more time on housework), and also relatively low for cohorts with high labour hours (as they have a greater income and therefore can dedicate a smaller share of it to services). However, we do not expect a great deal of variation in the budget shares across skill-gender cohorts. Budget shares are imputed on this basis according to a simple quadratic functional form in l, where:

$$S_B^Y = -0.375 + 3.5l - 4l^2, \qquad (8)$$

which yields values of between 0.25 and 0.4 for S_B^Y for most skill-gender cohorts (note that $0.25 < l < 0.56$ for 96 per cent of skill-gender cohorts).

Budget shares in this range lead to very small values for the third term in the labour supply elasticity [see equation (7)], contributing just 3 to 4 per cent of the total labour supply elasticity for most skill-gender cohorts.

2.3.3 Service production

The share of bought services in production S_B^S is assumed to be 0.5 for all cohorts. Therefore, $S_B^S = S_H^S = 0.5$. The value has a small impact on the labour supply elasticity, via the third term in equation (7), and variations in this value make very little difference to the labour supply elasticity.

2.3.4 Substitution elasticities

In this application we set $\rho = 0.08$ and $\eta = 0.12$. These values are chosen to yield labour supply elasticities that are broadly consistent with the literature. Based on these values, labour supply elasticities calculated according to equation (7) fall between 0.065 to 0.095 for women, and between 0.05 and 0.08 for men, as illustrated in Figure 2.

In comparison, Bento and Jacobsen (2007) and Taheripour *et al.* (2008) employ an uncompensated labour supply elasticity equal to 0.15, whilst Takeda (2007) employs 0.19.

Babiker *et al.* (2003) and Fischer and Fox (2007) calibrate their models to labour supply elasticities of 0.25 and 0.10, respectively. To address uncertainty over the value of the labour supply elasticity, Fraser and Waschik (2013) conduct a sensitivity analysis around the central case value of the labour supply elasticity +0.15, re-calibrating the model to a low value of 0.075 and high value equal to 0.30. In a review of the literature (specifically with regard to the U.S. labour market), Borjas (2015) finds that income effects generally dominate substitution effects for US males, driving a negative labour supply elasticity of -0.1. In contrast, substitution effects dominate for US females, driving a small positive labour supply elasticity of +0.2. Evers *et al.* (2008) also examine empirical estimates of labour supply elasticities by gender and across countries. The authors identify a median (uncompensated) labour supply elasticity for men of 0.08, while for women the figure is both higher and exhibits greater variability, with a median of 0.35.

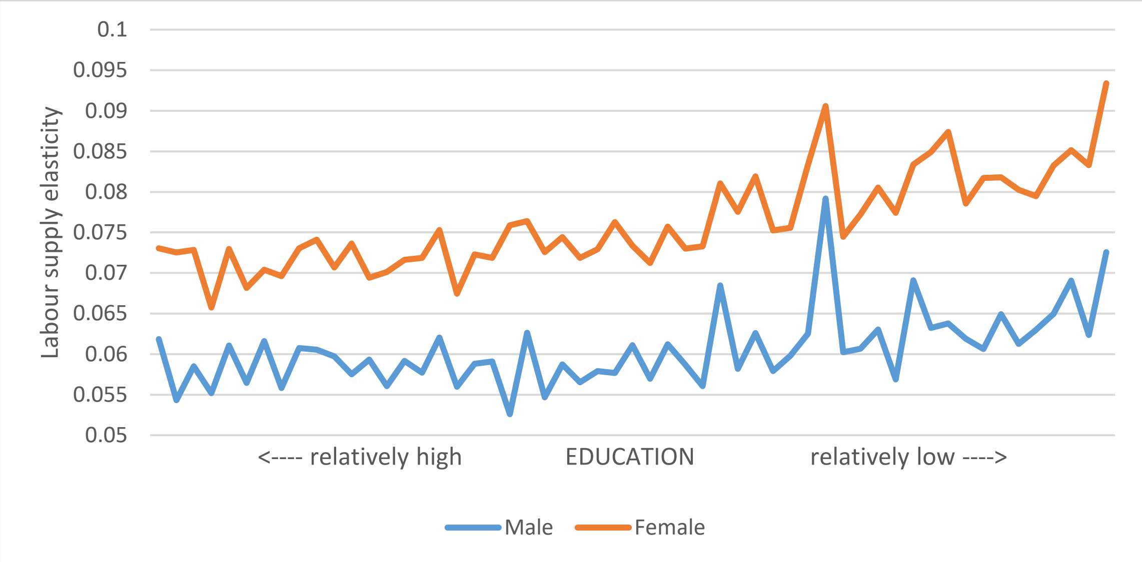

Figure 2: Labour supply elasticity by gender and skill group. Source: ABS Census 2016 and own calculations.

2.3.5 Limitations and areas for further development

Our aim in developing VUEF-G is to help policy makers quantify the impact of a range of economic policy issues on employment in general, but more broadly on employment by gender. As it stands, the model framework carries an equation system that achieves this primary goal. In terms of future development, we may enrich the equation system in order to account for potential policy implications for men and women arising from differences in lifetime earnings and wealth, ownership of assets and superannuation, and differences in consumption patterns or preferences.

Links to the main CGE framework at this stage are limited to the response of labour supply to the real (consumption price deflated) wage. An obvious avenue for further development is to link the "bought services" commodity to a suitable bundle of household consumption goods, including services such as child care, residential care and other services. At a later stage of development, subsidies for bought services, particularly child care, may also be explored.

3 Case studies: Exploring the efficacy of gender lensing in a CGE framework

In this section, we use VUEF-G to study three economic policy case studies and their impacts on male and female workers in Australia.

3.1 Case study 1: Do labour-saving productivity improvements benefit male or female workers?

Standard results for an unanticipated, labour-saving productivity improvement in a CGE model show that in the short-run, output increases but employment falls as the productivity improvement crowds out labour. This weakens the labour market and leads to a temporary decline in wages relative to the base case. Over time, employment and wages recover as stronger rates of return on capital drive investment above baseline, which in the long run translates to a higher overall capital stock. Over the medium-term, this stimulates employment in the construction sector. Being a male-dominated sector, in the medium-term the strength in the construction sector offsets the fall in average wages for men relative to women (Figure 3).

In the long run, the productivity improvement stimulates output in all sectors of the economy. Aggregate employment returns to its base case level, but changes in employment by industry are mixed. For some industries, the expansion in output achieved via the productivity gain only, while employment contracts, while other industries expand both output and employment. Overall, the improvement in productivity leads to an improvement in international competitiveness, giving the greatest stimulus to output and employment in labour-intensive, trade-exposed industries, e.g., manufacturing, tourism, education and professional services. As these sectors do not have a strong gender bias in the workforce, the long-run impacts of a productivity gain are fairly gender neutral.

Figure 3: Labour market impacts of an unanticipated labour-saving productivity improvement. Source VUEF-G.

3.2 Case study 2: Do male or female workers benefit more from an agri-food export boom in Australia?

In this application, we consider a one-off (permanent) outward shift in the export demand schedule for agri-food products.[3] The immediate effect of the export demand shift is to increase the prices and volumes of agri-food exports, causing the exchange rate to appreciate and exports of all other commodities to decline. There is also a surge in construction activity, to support capital formation in the agri-food sector.

The boom gradually strengthens real wages, leading to increased activity in sectors that largely service the domestic economy, e.g., retail, health care and social assistance, and public administration and safety. The timing of these impacts imparts a time-dimension on the gender impacts of the policy: the initial increase construction benefits male workers, and is then followed by an increase in employment in sectors with a larger share of female employees. This is reflected in the results for men's and women's wages, which are shown in Figure 4.

[3] In VUEF, to a large extent agricultural products are not directly exported, but are sold into the manufacturing sector from which they are exported as food products.

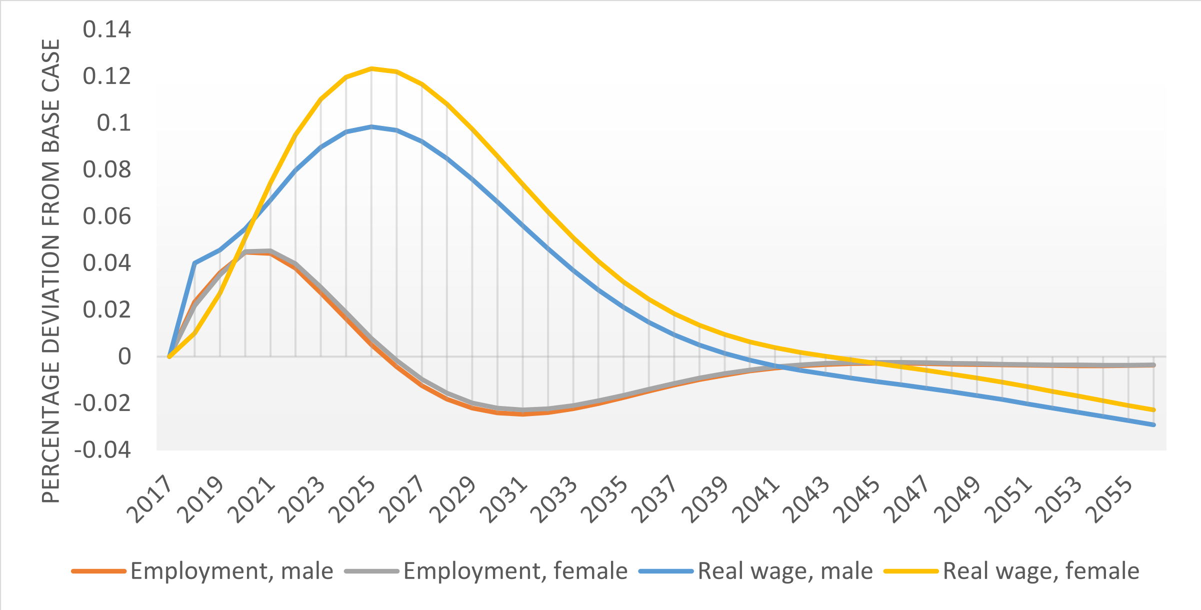

Figure 4: Labour market impacts of an unanticipated boom in export demand for agri-food products. Source VUEF-G.

3.3 Example 3: Are gender differences evident in a reduction in Australia's corporate income tax rate?

What are the macroeconomic effects of a cut to the rate of company tax in Australia? For a full description, we refer the reader to Dixon and Nassios (2018). Here, we summarise the impacts. Cutting Australia's company tax rate:

i. Triggers a fall in tax revenue derived from foreign-owned capital stocks; and
ii. Stimulates foreign investment in Australia relative to domestic investment.
iii. In the long-run, this requires Australia to reduce its trade deficit, leading to expansions in trade-exposed sectors such as agriculture, as well as mining and manufacturing. In contrast, local, service-based sectors such as health care, education and retail, all contract.
iv. A more capital-intensive economy devotes more resources to the maintenance of its capital stock. This stimulates employment in the construction sector.

A preliminary top-down analysis indicates that a cut to the rate of company tax is damaging to the employment of women, relative to the employment of men [J. Dixon (2018)]. Industries that benefit in an output sense when the company tax rate is reduced, contain male-dominated workforces, while industries' whose output contracts are large employers of women. Results from the VUEF-G model confirm this; the degree to which wages and workforce participation change when the company tax rate is cut is illustrated in Figure 5. Although pre-tax real wages increase for both men and women, the increase in the average wage for men is greater than the increase for women.

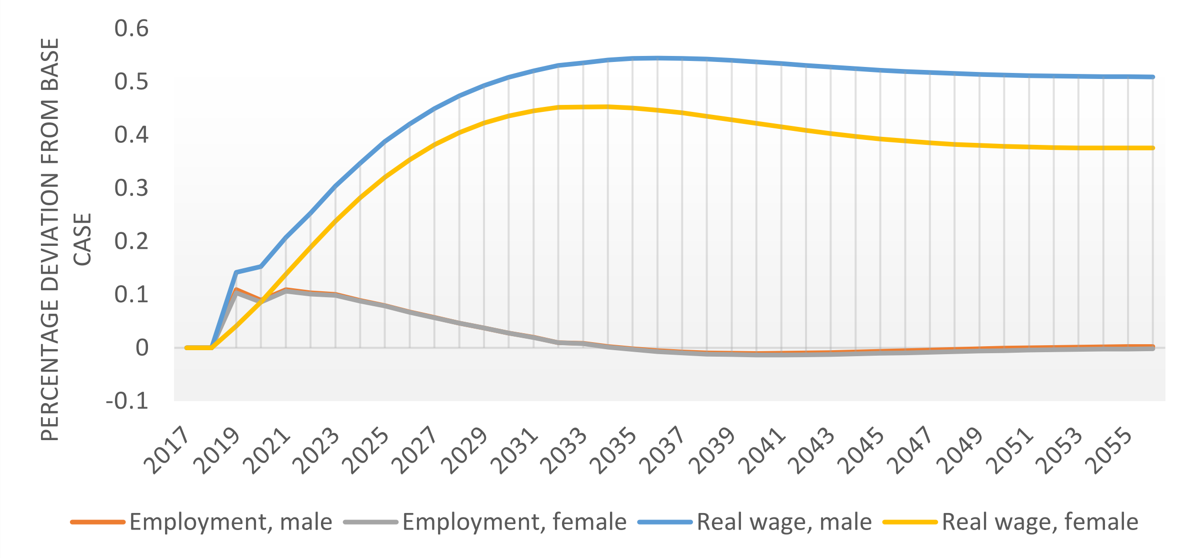

Figure 5: Labour market impacts of a cut to the rate of company tax. Source VUEF-G.

4 Concluding remarks

Many industries in the Australian economy have strongly gendered employment. As such, changes in economic conditions, either deliberately imposed (such as a change to a tax rate) or exogenous (such as productivity growth or an export boom), can lead to disproportionate labour market outcomes for men and women. The enhancements to VUEF described herein provide policy markers with a framework that can be used to assess these differential effects. In so doing, the VUEF-G model builds on the rich pedigree of CGE policy assessment tools, by providing results for the impacts on wages, participation rates and employment across male and female workers.

The model takes into account two key features of the labour market: the gender composition of employment in each industry, and the elasticity of labour supply for each skill-gender cohort. Skills and industries are linked through the supply and demand for occupations. Within the CGE model, labour supply elasticities are derived from a labour-leisure choice module, which is extended to take into account time used on unpaid domestic services that are produced and consumed by the household. There is a clear tendency in the Australian population for women to dedicate more time to unpaid domestic services. This leads to higher labour supply elasticities for women, and consequently to relatively high labour supply elasticities for occupations with higher rates of female employment. These features of the Australian labour force are naturally represented within the VUEF-G model.

Using three case studies, we illustrate the potential of this model. We show that an increase in productivity leads to stronger wages economy-wide, with little gender bias. The benefits are largely dispersed across many sectors of the economy, and thus equally shared by male and female workers. The benefits of a boom in agri-food exports are less evenly distributed: women's average wages benefit by more than male wages, because the stronger real exchange rate boosts consumption and retail employment, while crowding out employment in traditionally male-dominated export industries, e.g., mining. The biggest discrepancy between the male and female wage outcomes is however evident in our final case study, where we study a cut to the rate of company tax in Australia. In this example, trade-exposed sectors expand while domestic service sectors (such as health, retail and the public sector) contract. The average pre-tax wage of both men and women increase, but the increase in the men's average wage is around one-third larger than the increase in the women's average.

The examples presented illustrate the utility of our modelling framework. At this stage of development, VUEF-G has the capacity to provide valuable insights into the gender impacts of any policy that naturally lends itself to a CGE assessment. In future, we expect that the model will be enhanced by a more thorough treatment of the pricing and usage of bought services. For example, we anticipate developing new theory to model the linkages between the model's "price of services", and the tax and transfer system, e.g., in the area of child care subsidies. This would enhance the capacity of the model to assess the impact of changes to this system on labour force participation by primary carers, and on the economy more widely.

Australia was a pioneer in gender budgeting, but has fallen behind in recent years [Stewart (2016)]. In this paper, we have shown how VUEF-G can help understand the differential impact of economic policy reforms on male and female workers, and also assist with gender budgeting in a systematic manner. CGE modelling has long been used to identify winners and losers from economic policy reforms, specifically in terms of industries, regions and occupations. With its many indirect linkages, CGE modelling often identifies inadvertent or unintended policy consequences, making it an ideal tool for gender budgeting. We hope that Australia may soon return to the international forefront in gender budgeting, and that VUEF-G may play a role in facilitating this.

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